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## (54) Making printed circuit boards having plated through-holes

(57) A one- or two-sided metal-foil-  
coated base material 1 is used  
which, upon production of the hole  
pattern, is provided in a known  
manner with a metal layer 3 of  
desired thickness, said layer cover-  
ing the surface of the metal foil 2  
as well as the hole walls. Subse-

quently, a masking layer 4 is ap-  
plied by screen printing a positive  
image of the desired circuit pattern  
on the surface(s). The holes are  
then filled with an ink 7 by means  
of a screen printing stencil, the ink  
forming an etch-resistant surface  
film 70 when dry. After etching,  
the masking layer as well as the  
surface film and the hole fillings are  
removed with a suitable solvent.

The screen printing stencil com-  
prises a carrier screen fixed to a  
frame, said carrier screen being pro-  
vided on its side facing the surface  
to be printed with a metal or plastic  
foil, said screen and foil being pro-  
vided with holes at locations corre-  
sponding to the hole pattern in the  
base material.

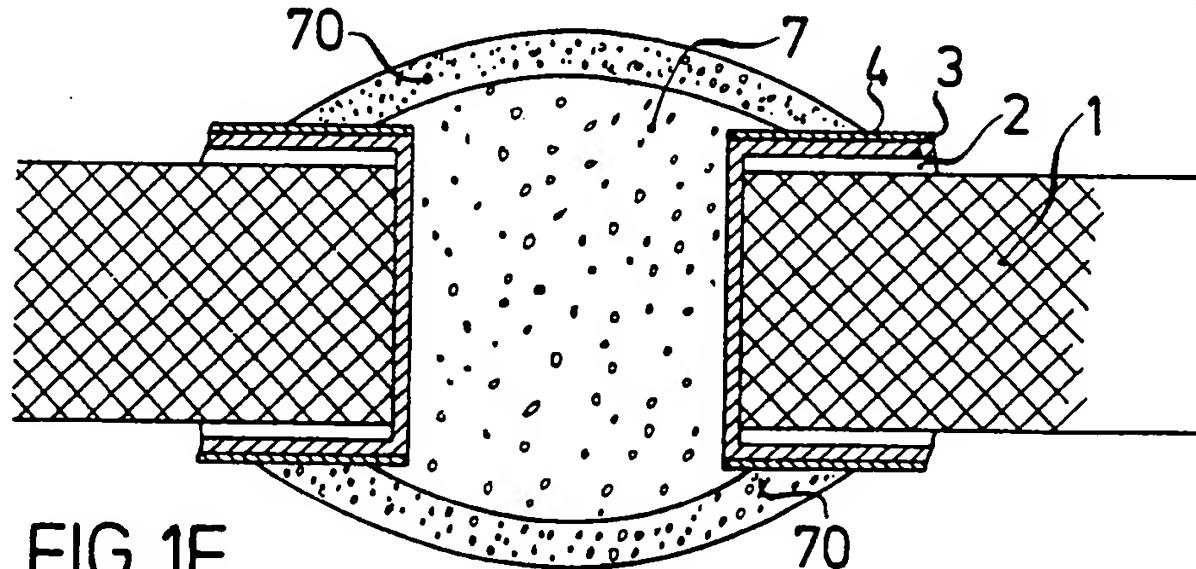


FIG.1E

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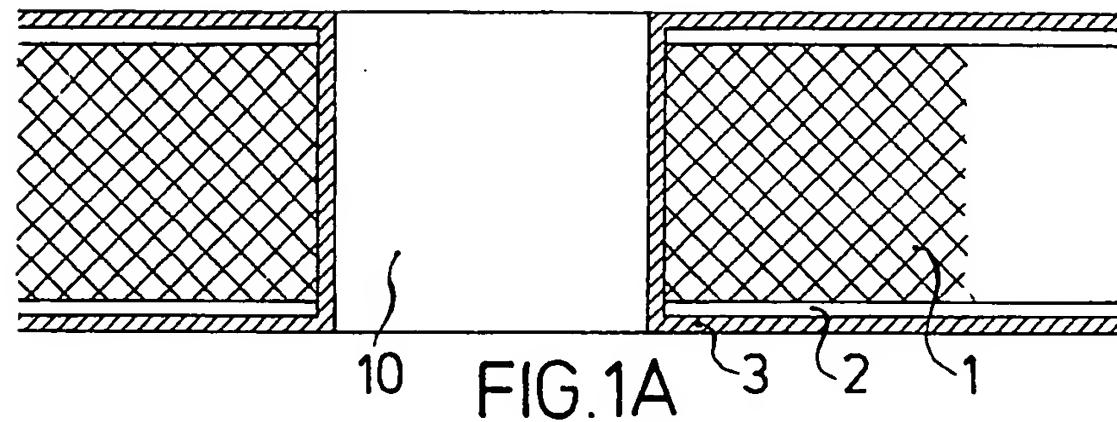


FIG. 1B

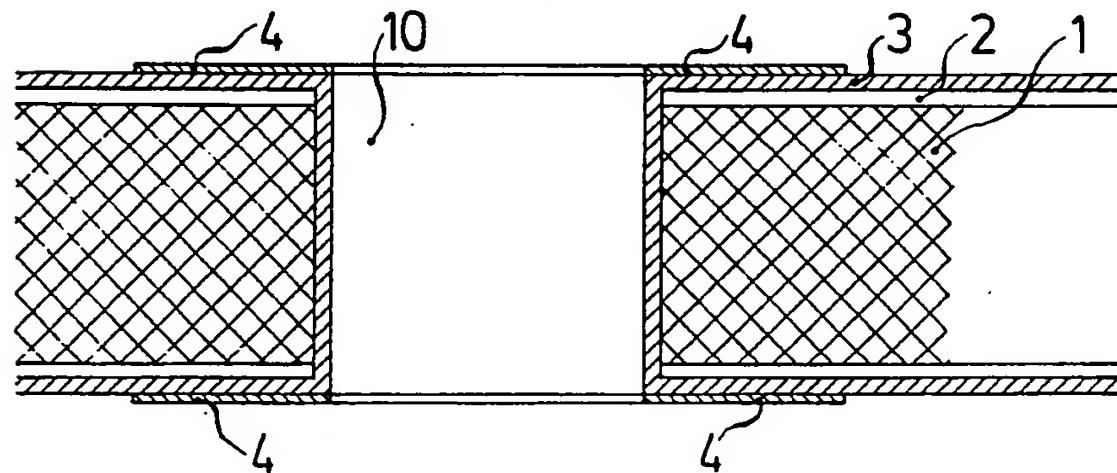
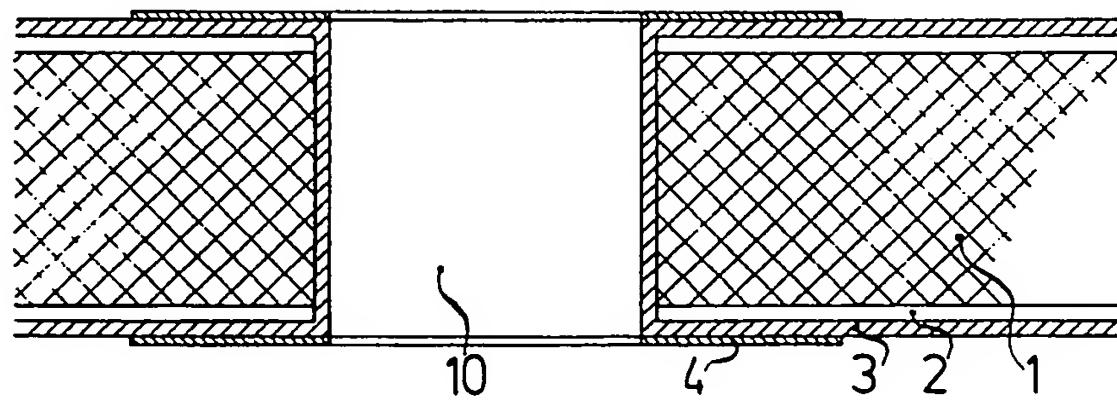
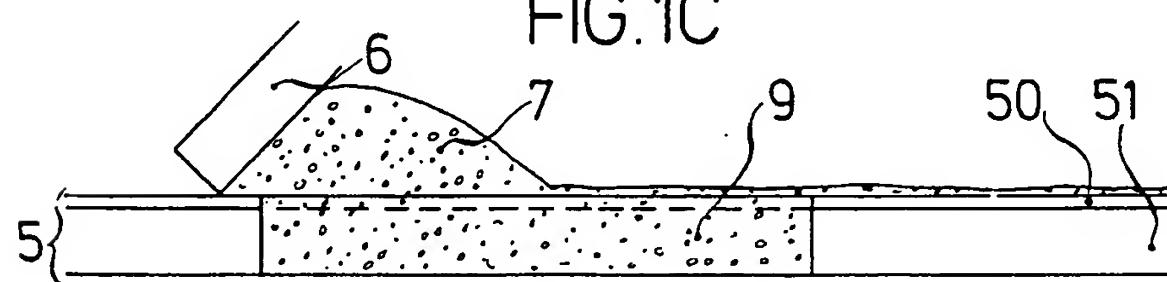


FIG. 1C



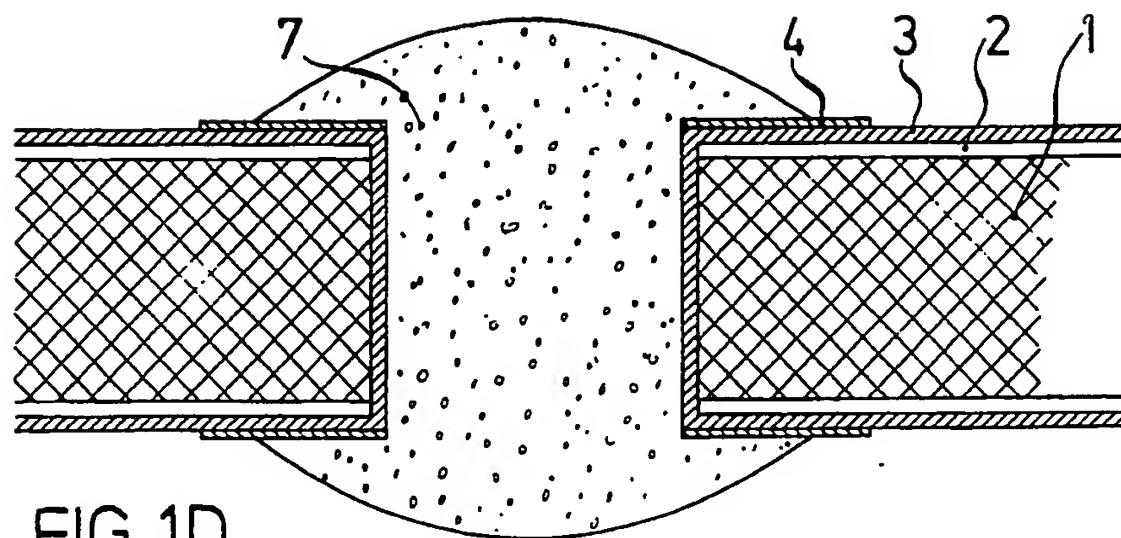


FIG. 1D

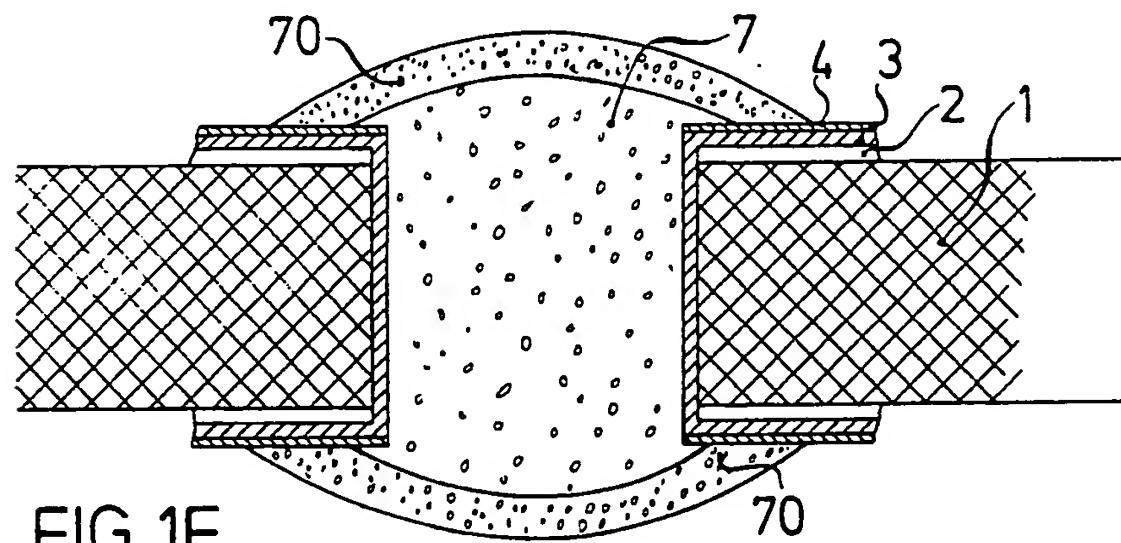


FIG. 1E

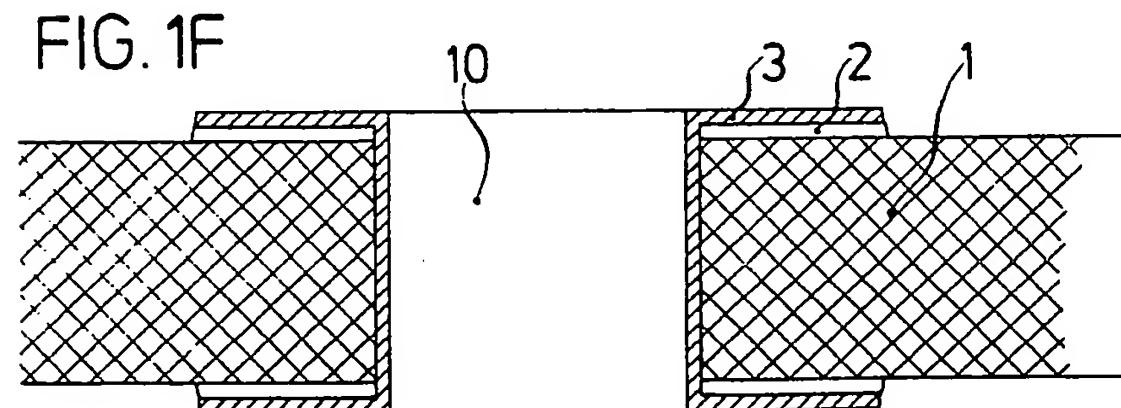


FIG. 1F

## SPECIFICATION

### Process and device for the manufacture of printed circuit boards

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The present invention relates to a process for the manufacture of printed circuit boards provided with holes having metallized walls and, particularly, to such boards provided with copper conductors and copper-plated hole walls.

For manufacturing such printed circuit boards, a number of processes have been suggested. In one of those processes the conductors as well as the hole walls are provided with a metal layer serving as an etch-resist during the subsequent etching step and being removed afterwards. Preferred metals or metal alloys to be used as etch-resistant metal layers are such metals which can easily be removed without adversely affecting the copper surface as, for example, tin or tin/lead alloys.

Independent of the poor economy of such process, its high reject rates, too, make it unsuitable for mass production; especially, it has proven to be difficult to achieve a copper surface with good solderability.

Furthermore, it has been suggested—for two-sided copper clad boards—to provide the holes in a first step and, subsequently, to deposit copper on the hole walls by electroless copper deposition or by electroless copper deposition followed by electroplating until a desired thickness of the copper layer on the hole walls and the surface of the base material is achieved. Subsequently, the surface of the base material is covered on both sides with a photoresist dry film of suitable thickness. Upon exposure through a positive of the desired printed circuit pattern and developing, an etch-resistant mask is formed which, on the one hand, covers the copper surface corresponding to the desired circuit pattern and, on the other hand, the holes thereby sealing them hermetically. The copper in the exposed areas is removed in a subsequent etching step. After removal of the masking layer, the circuit board shows copper conductors and copper-clad hole walls well suited for soldering.

The high costs of suitable photoresist dry films and the photoprinting process itself constitute a considerable disadvantage of this process whenever conductor width and density would allow screenprinting methods.

Therefore, it has been suggested, instead of using a photoresist dry film, to fill the holes with an etch-resistant ink using, for example, a squeegee. Before or after the removal of the said ink from the surface, the ink inside the holes is hardened by heat curing. Subsequently, an etch-resistant mask corresponding to the positive of the conductor pattern is applied by screen printing. After etching, the said etch-resistant mask as well as the hole

fillings have to be removed. The removal of the dried and hardened ink from the surface prior to screen printing has proven to be a very tedious process, normally to be per-

formed by precision polishing. Furthermore, it has also proven to be costly and difficult to remove all hole-fill left overs from the hole walls after etching. Therefore, this process is not suited for mass production purposes as it requires very thorough processing to achieve acceptable reject rates.

The process in accordance with the present invention avoids the problems and disadvantages described hereinabove and provides a safe and economic process for producing printed circuit boards with copper conductors and copper-clad hole walls.

In accordance with the present invention there is provided a process for the manufacture of printed circuit boards with metallized hole walls on any suitable insulating base material provided on one or both sides with a metal layer comprising the steps of providing said base material with those holes whose walls are metal-coated in the finished circuit board, and depositing a metal layer of desired thickness on the walls of said holes and the surface or selected areas of the surface of said base material in known manner, characterized in that a masking layer is applied to said metal-coated surface(s) of said base material by screen printing a positive image of the desired circuit pattern; and that said holes provided with metallized walls are subsequently filled with a resinous ink composition employing a screen printing stencil provided on the side facing the surface of said base material during use with a foil securely fixed to the screen of said stencil; and that said screen and said foil are provided with holes at locations corresponding to the holes with metallized walls in the circuit pattern; and that said resinous ink composition is pressed into the holes of said base material by means of a squeegee; and that the unmasked areas of the metal layer on the surface of said base material are etched away in known manner; and, finally, that the masking layer applied by screen printing and the said ink composition in said holes are removed by the agency of one or more suitable solvents.

A metal-clad base material, for example a two-sided copper-clad insulating base like, e.g., a laminate, hereinafter called base material, of suitable size, is provided with holes to be coated with a metal layer. Subsequently, a copper layer of desired thickness is deposited in a well known manner on the surface of the base material and the hole walls.

Then, a masking layer corresponding to the desired printed circuit pattern is screen printed onto the base material, preferably using a scratch-resistant screen printing ink which is hardenable by UV radiation. Subsequently, the holes are filled with an etch-

resistant material using a screen printing stencil in accordance with the present invention, said stencil being manufactured by fixing a suitable screen in a frame, said screen being 5 provided on the side facing the surface to be printed with a foil of metal or plastic material of a thickness of 0,1 mm or less. In accordance with one embodiment of the present invention an aluminum foil is fixed to the 10 screen by means of an adhesive.

Screen and foil are provided with holes, preferably by drilling, in a pattern which corresponds to the hole pattern of the finished circuit board. Preferably, the diameter of the 15 holes in the screen and foil is larger than the diameter of the holes in the base material, but should not exceed the limit of the etch-resistant mask applied by screen printing. As a rule, the diameter of the holes in the screen 20 and foil is only slightly in excess of the diameter of the holes in the base material.

In a further screen printing step, the ink for protecting the hole walls is pressed into the holes through the screen by means of a 25 squeegee. Preferably, a protective ink is used which—under the influence of dry air and the oxygen contained therein—forms an etch-resistant surface film covering the holes, while the ink inside the holes remains almost or 30 completely viscous. Thereby, the removal of the hole filling in a later process step is easily achievable using a solvent or a thinner for the respective ink.

For a better understanding of the scope of 35 the invention, reference is made to the following description of the drawings.

Figures 1A to 1F show in a diagrammatic view the base material during the different process steps of the process in accordance 40 with the invention.

Fig. 1A shows a partial view of the base material 1 covered on both sides with a copper foil 2. The walls of the holes 10 as 45 well as the surface of the copper foil 2 are provided with a copper layer 3 deposited by methods well known in the art.

Fig. 1B is the partial view of the board of Fig. 1A after applying an etch-resistant mask 4 by screen printing.

Fig. 1C is a diagrammatic view of the 50 screen printing stencil 5 with the holes 9 in proportion to the holes 10 of the base material 1. The screen printing stencil 5 comprises the carrier screen 50 and the thereto 55 adhered stencil foil 51. The hole 9 is already filled with the ink 7 by means of the squeegee 6.

Fig. 1D shows the board 1 with the hole 10 filled with the ink 7.

Fig. 1E shows the board of Fig. 1D after 60 drying; the viscous-fluid ink filling 7 of hole 10 is covered by an etch-resistant film 70 formed on the surface of the filling 7.

Fig. 1F shows the finished printed circuit 65 board in accordance with the present inven-

tion after removal of the etch-resistant mask 4 (Fig. 1E) and the ink filling 7 including the film 70 from the hole 10. The copper conductors as well as the copper layer on the hole 70 walls is of excellent solderability.

The present invention is neither limited to copper-clad base material nor to copperized hole walls. Furthermore, the metal layer on the surface of the insulating base material has 75 not necessarily to be a laminated copper foil, but can be produced by electroless metal deposition as well as electroless metal deposition followed by electroplating.

The scope of the invention will be still 80 better understood from the following examples.

#### Example 1.

The base material used in this example is a 85 glassfiber reinforced epoxy resin laminate provided on both sides with a 35  $\mu\text{m}$  thick copper foil. After the boards are cut to size, the manufacturing process comprises the following steps:

90 (1) Providing those holes in the base material whose walls are to be metallized;

(2) Brushing to remove the burr surrounding the hole wall edges;

(3) Cleaning with a cleaner conditioner at

95 70°C for 5 minutes;

(4) Rinsing with water at 50°C for 5 minutes;

(5) Slightly etching the copper foil surface with a solution of ammoniumpersulfate at

100 50°C for 1 minute;

(6) Carefully rinsing in water;

(7) Immersing into a sodiumchloride pre-catalysing solution;

(8) Catalysing by immersing into a Sn(II)

105 Pd(II)Cl catalysing solution at room temperature for 2 minutes;

(9) Rinsing;

(10) Immersing into a commercially available electroless copper deposition bath at

110 room temperature for 45 minutes;

(11) Building-up the copper layer on the hole walls to 35  $\mu\text{m}$  by electroplating;

(12) Rinsing and drying;

(13) Applying the etch-resistant mask corresponding to the desired circuit pattern by screen printing and air dry;

(14) Filling the holes by screen printing using the same ink as in step (13) and a screen printing stencil comprising a screen

120 having adhered to its lower surface an aluminum foil of 0,8 mm thickness. The screen and the foil are provided with holes corresponding to the pattern of the finished board consisting of holes with metallized walls;

125 (15) Air-drying to form an etch-resistant film sealing the hole fillings;

(16) Etching in a hydrogenperoxyde-containing hydrochloric acidic copper chloride solution;

130 (17) Removing the etch-resistant mask as

well as the hole fillings with trichlorethylene and a spray etcher.

*Example 2*

5 The base material is an epoxy resin paper provided on both sides with an adhesive layer. The board is first provided with those holes whose walls are to be metallized. The adhesive layer is rendered wettable and microporous in a known manner. Subsequently, the surface including the hole walls are catalysed for the deposition of copper from electroless copper deposition baths; then, a thin copper layer is deposited from a commercially available electroless deposition bath. The further process steps are as described in Example 1, steps (11) through (17).

*Example 3*

20 The process of Examples 1 or 2 is used; in step (13), however, a UV-curable screen printing ink is employed and the printed mask is cured by UV radiation.

*Example 4*

The process of Example 3 is used, with the copper layer being produced solely by electroless copper deposition.

**30 CLAIMS**

1. A process for the manufacture of printed circuit boards with metallized hole walls on any suitable insulating base material provided on one or both sides with a metal layer comprising the steps of providing said base material with those holes whose walls are metal-coated in the finished circuit board, and depositing a metal layer of desired thickness on the walls of said holes and the surface or selected areas of the surface of said base material in known manner, characterized in that a masking layer is applied to said metal-coated surface(s) of said base material by screen printing a positive image of the desired circuit pattern; and that said holes provided with metallized walls are subsequently filled with a resinous ink composition employing a screen printing stencil provided on the side facing the surface of said base material during use with a foil securely fixed to the screen of said stencil; and that said screen and said foil are provided with holes at locations corresponding to the holes with metallized walls in the circuit pattern; and that said resinous ink composition is pressed into the holes of said base material by means of a squeegee; and that the unmasked areas of the metal layer on the surface of said base material are etched away in known manner; and, finally, that the masking layer applied by screen printing and the said ink composition in said holes are removed by the agency of one or more suitable solvents.

2. The process of claim 1, characterized in that the holes in the screen stencil and the foil

attached to it have a larger diameter than the holes in the base material, thus securing that, when applying the resinous ink composition to fill the holes, all areas not covered with the etching mask remain free of said resinous ink composition.

3. The process of claim 1 or 2, characterized in that the holes in the screen and the foil are produced by drilling.

75 4. The process of claims 1 to 3, characterized in that the resinous ink composition used for filling the holes, when drying, forms an etch-resistant film on the surface while the ink composition in the holes underneath the surface film remains in a state of high viscosity.

5. The process of claim 1, characterized in that the screen printable ink composition(s) used for producing the etch-resistant masking layer is (are) hardened by UV-radiation.

85 6. The process of claims 1 to 5, characterized in that the metal layer covering the surface of the base material as well as the hole walls is copper.

7. The process of claim 1, characterized in that the foil of the screen printing stencil is fixed to the screen by means of an adhesive.

8. The process of claims 1 and 7, characterized in that said foil has a thickness of 0,1 mm or less.

95 9. The process of claims 1, 7 and 8, characterized in that the foil is a metal foil and, preferably, an aluminum foil.

10. The process of claims 1, 7 and 8, characterized in that the foil is a plastic foil.

100 11. Screen printing stencil for working the process of claim 1, characterized in that the screen is fastened to the frame and is provided with a foil, said foil being securely fixed to the surface of said screen which is not in contact with the squeegee during the hole filling process; and that said screen and said foil are provided with holes at locations corresponding to the hole pattern in the base material.

110 12. The screen printing stencil of claim 11, characterized in that the foil is a plastic or a metal foil of a maximal thickness of 0,1 mm.

13. The screen printing stencil of claim 115 11, characterized in that the foil is fixed to the screen by means of an adhesive.